Studying Fog and the Chemistry of the Air in Iqaluit
Technical Summary

Rationale and Objectives:

Coastal communities experience unique atmospheric chemistry due to the interactions of human emissions and natural marine sources such as marine biological activity and sea spray. This is particularly true of northern ports such as Iqaluit where the background atmosphere is very clean, possibly allowing even small emissions to dominate the atmospheric chemistry. Coastal communities are also often frequently influenced by low visibility due to fog advected from nearby bodies of water, affecting marine and air transportation. The formation, visibility and dissipation of this fog can be influenced by the properties of the aerosol particles suspended in the atmosphere such as number, size and chemical composition. Furthermore, fog droplets can provide additional pathways for chemical and physical processing of atmospheric gases and particles to occur.

While past studies to understand the atmospheric chemistry of coastal locations have been conducted in heavily polluted locations in the United States, very few studies have targeted latitudes and conditions more relevant to Canadian coastal communities, especially in the Arctic where shipping emissions are expected to increase in the future and unique chemistry occurs in the summer due to the long summer days and low background concentrations.

The objectives of this project are to study the chemistry of the atmosphere in Iqaluit, especially the interactions between ocean and human emissions in a clean background, as well as the properties of any fog events that occur and their relationship to the aerosol particles. These observations can then be used to constrain air quality models, such as GEM-MACH operated by Environment and Climate Change Canada (ECCC), and would also be relevant for human exposure and climate studies.

Progress to Date

A study with a similar suite of instruments was conducted in Halifax, Nova Scotia during June 2019. Our preliminary results showed higher than expected levels of organic and amine compounds in the aerosol particles. Additional work is still required to understand the origin of this aerosol mass as well as the gas phase chemistry. These results will provide an important point of comparison for the measurements to be conducted in Iqaluit.

An analysis of visibility data from Iqaluit shows that fog during the summer is rare because of the strong winds. Unfortunately, the timing of this study is limited by logistical constraints. As such, the objectives associated with fog are secondary.

Methodology

We hope to conduct the onsite portion of our study for approximately 30 days in the window of July to September 2021, but this will depend on when (if at all) travel restrictions are lifted due to COVID-19. Measurements will be conducted at the existing Iqaluit meteorological

site that is part of the Canadian Arctic Weather Science project conducted by ECCC at the Iqaluit Airport southwest of the runway. Most of the equipment will be housed inside a temporary 10' x 6' trailer that will be installed near the existing meteorological equipment on the site for the duration of the study. Three additional instruments will be operating outside of the trailer, with their exact locations on site still to be determined. However, it is expected that they will be within 100 m of the trailer.

Instruments deployed will measure criteria pollutants (O3, NO, NO2), and other gases relevant for climate and air quality, like CO2, CH4 and HCl, as well as the chemical and physical properties of the particulate matter. A list of the proposed instruments is listed in the table below.

Instrument	Property
Fourier Transform Infrared Spectrometer	CO2, CH4, CO, volatile organic compounds and other trace gases
Medium Volume Sampler x 2	Aerosol chemical composition
Scanning Mobility Particle Sizer	Aerosol size distribution
Aerodynamic Particle Sizer	Aerosol size distribution
Aerosol Chemical Speciation Monitor	Non-refractory aerosol chemical composition
Cloud Condensation Nuclei Counter	Cloud condensation nuclei
Gas phase instruments	O3, NO, NO2, HCl

All of the instruments measure in real time except the Medium Volume Samplers which are filter-based. These filters will be analyzed for their chemical properties after the study ends.

Anticipated results are an improved understanding of the chemistry that occurs between oxidants emitted from oceanic sources and volatile organic compounds emitted from anthropogenic sources, as well as a better understanding of the budget of these compounds in Iqaluit. Interactions between the gases and aerosol particles will also be investigated. Furthermore, an improved understanding of the effects of aerosol properties on visibility during fog events is expected with our measurements, which will be analyzed in relation to the fog droplet size distribution and visibility measurements that already exist on site. Finally, our observational results will be compared to model output such as ECCC's GEM-MACH air quality model.

Data Management and Research Outputs:

During the study, data measured in real time will be saved on computers and backed up daily on portable hard drives. Intermediate data and metadata used in analysis will be shared among the research groups through a server and the finalized dataset will be published on the openly accessible Dataverse via Dalhousie University. The dataset will also be shared with ECCC for future comparison with output from their air quality model.

It is expected that the results from this work will be presented at various national and international conferences, lead to peer-reviewed scientific publications and be an integral part of the theses of at least two graduate students. They will also be presented to the Science and Technology Branch of ECCC, in the form of a presentation and a written report. Furthermore, the results will also be shared with relevant parts of the Environmental Protection division of Nunavut as well as any other interested parties.